



“SURFING IN THE CELL” - AN INVESTIGATIVE GAME FOR TEACHING CYTOSKELETON CONCEPTS FOR UNDERGRADUATE STUDENTS

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Resumen

The educational role of games becomes evident as students are more active, able to take decisions, solve problems and react to the results of their own decisions. The educative board game *Discovering the Cell* is based on problem-solving learning. This game challenges students to collect, discuss and interpret clues in order to decipher a question. In this work we evaluated the game as a tool for teaching health sciences undergraduate students from Rio de Janeiro. In a questionnaire-based analysis, students demonstrated great acceptance for this strategy and the majority of them were able to solve the Case tested, as well as applying the learned content to answer a related question. Taken together, our results indicate the acceptance and suitability of the game as an alternative strategy to help teaching cell and molecular biology to undergraduate students.

Goals:

We aimed to investigate the acceptance and suitability of a game for teaching cell biology subjects to undergraduate students from health sciences courses. In this study we choose to teach up-to-date information about the cytoskeleton. We evaluated student's acceptance of playing the game, their ability to solve the proposed problem and to apply the learned content in a test question.

Introduction:

The role of games within an educational context is evidenced as students become more active, able to take decisions, solve problems and react to the results of their own decisions (Macedo *et al*, 2000). Several educational strategies involving games and ludic activities have been described in the literature for both secondary and undergraduate students.

The educational board game *Discovering the Cell (Célula Adentro)* is based on the problem-solving learning approach (Pozo, 1998) and shares some features with inquiry-based learning (Chinn and Malhotra, 2002), as it challenges players to formulate their own theories by relating results of several research works and previously described concepts. This game has been demonstrated as a suitable alternative strategy to help teach Cell and Molecular Biology themes to secondary-level students (Spiegel *et al.*, 2008).

Brazilian educational system faces the problem of a large amount of contents and subjects to be presented on relatively short periods. Therefore, games and other ludic activities can be regarded by undergraduate students as childish and time-consuming, being more suited to primary and, to some extent, secondary levels. In this work, we addressed the suitability of a problem based game to teach Cytoskeleton functions and structure to undergraduate students. As the majority of our students are of biomedical related careers, we believe that themes related to health problems are a better way to promote students' interest. In this manner, we have decided to introduce the cytoskeleton topic by discussing Herpes virus infection of neurons using the game *Discovering the Cell* with the Case "Surfing in the Cell".

Methods:

Overview of the game:

The Case "Surfing in the Cell" starts with a brief description of the process of infection of human cells by the Herpes simplex virus and its necessity of reaching the host nucleus to complete their replication cycle.

Students play in teams and must explain how the virus manages to reach the nucleus. They do so by collecting, discussing and interpreting several *Clue cards*. **Table 1** shows the brief content of these cards, which depict texts, tables, images, schemes or results of experiments – with the aim of stimulating students to interpret scientific data. The first team to figure out an answer to the Case under investigation and to announce a correct and justified solution is the winner. For a more detailed description of the game, see Spiegel et al. (2008).

Table 1: Content presented on the Clue cards for the Case “Surfing in the Cell”

Clue	Issue	Function in the game
1	Text: Effects of human infection by Herpes simplex virus	Gives the students up-to-date information on the health significance of Herpes, and its ways of infection
2	Scheme: the three components of the cytoskeleton	Shows that cytoskeleton is composed by different component proteins, with singular characteristics and cellular functions
3	Table: total time of travel along the cytoplasm	Shows that the viscosity of the cytoplasm denies the virus the possibility of reaching the nucleus in a short period by mere diffusion.
4	Text + electron microscopy: motor proteins	Shows a vesicle traveling through the cytoplasm with the help of motor proteins, with spending of ATP.
5	Text: the dynamic cytoskeleton	Describes the dynamic character of the cytoskeleton elements, and its role on different cellular functions.
6	Fluorescence microscopy + text: colocalization of mitochondria and microtubules	Represents, in two images, the colocalization of mitochondria and the microtubule network on the same cell.
7	Text + light microscopy + scheme: color pattern change on a fish scale	Shows that some fishes can promote changes in their color patterns by moving pigment vesicles along the microtubules, from the membrane to the centrosome, next to the nucleus.
8	Text + Experiment: disrupting the cytoskeleton	Shows the effects of <i>taxol</i> , drug that stabilizes microtubules, and <i>necodazole</i> , which disrupts the microtubule network, on the viral capacity to reach the nucleus
9	Text + Experiment: the velocity of organelles	Represents the speed measured for Herpes virus traveling along the axons of infected neurons, and compares this speed with that found for cell organelles.
10	Text + fluorescence microscopy + scheme: <i>Lysine monooxygenase</i>	Shows a bacterium which induces the formation of an actin-tail to promote locomotion inside the host cell.

Evaluation:

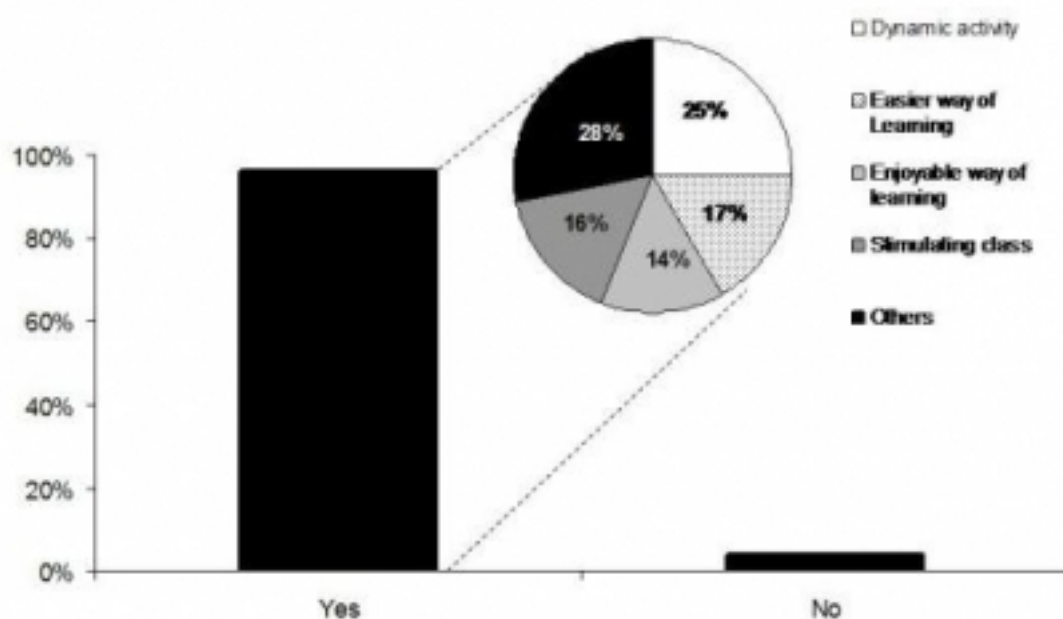
The game was tested with 87 teams (2 to 3 players) totalizing 180 students from different courses (pharmacy, dentistry and medicine) from a public federal university in Rio de Janeiro. The experimental approach for the evaluation consisted of the application of written instruments (questionnaires and *notepads*), as described on previous works (Cardona *et al.* 2007; Spiegel *et al.* 2008). Questionnaires were analyzed both qualitatively and quantitatively. Special attention was given to game playability and acceptance, as well as to the learning of the subject approached in the Case. Teams also evaluated their comprehension of each clue by using a 1 (equivalent to “I did not understand”) to 7 (“I understood everything”) scale. A similar 1 to 7

scale (ranging from “very hard” to “very easy”) was used to evaluate the easiness of the Case. In order to determine the number of teams that were able to achieve a correct solution, all teams were asked to continue playing and to write down their answer. An informal discussion about the activity was performed after session of game playing. Students were also asked to answer individually an additional *related question*, aimed to assess whether the students could apply the content learned while playing to solve a problem situation. The related question consists of a scheme of the glucose transporters travelling in vesicles to the plasma membrane after insulin stimulation. Students were expected to identify how the vesicles move through the cytoplasm. Finally, a month after the game class, the central question of the case was applied on a test in order to assay content retention.

Results and Discussion:

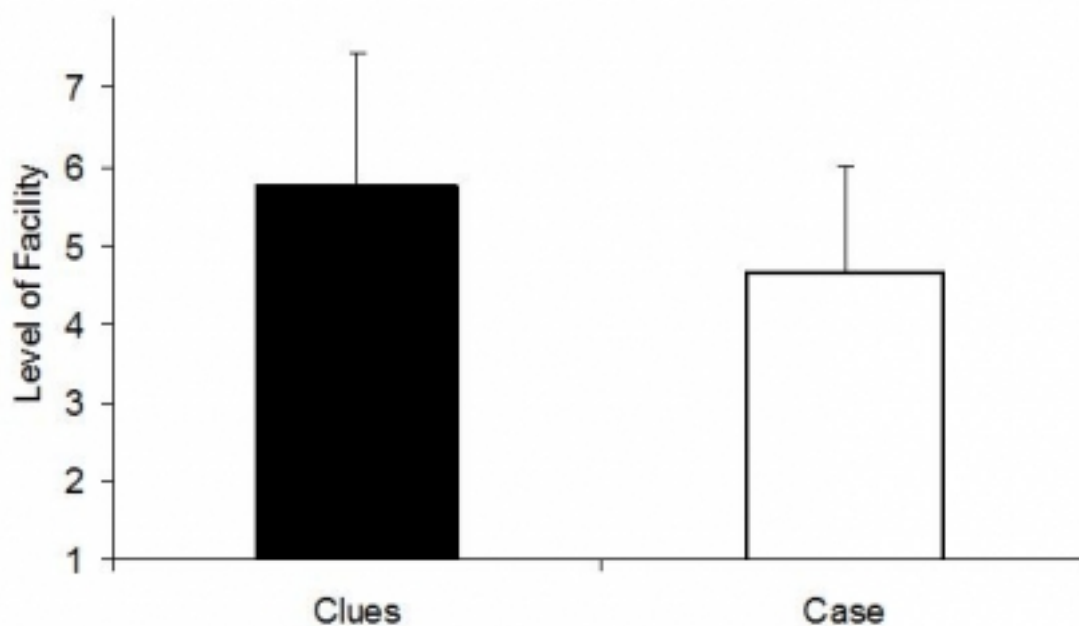
Figure 1 describes the acceptability of the game. Most of the students (97.2%) would like to have more classes using the game. This affirmative was justified by many reasons, which were grouped in 5 descriptive categories (Figure 1, insert). Students identified the game as a problem-based strategy, as confirmed by statements such as: *“The game allowed reaching our own conclusions. It is much better than just stick to the old blackboard”* or *“...with this kind of activity we already begun to have a scientific thinking, observing what is happening and, with some information available, trying to solve a problem”*. Although the majority of them would like to play the game again, some were quite worried that they could learn a larger amount of content in the usual lectures, as in *“The game is cool, but I do prefer expositive classes since there is more content”*. In spite of these comments, some students recognize that *“maybe what we have seen [in the game] we won’t forget; you assimilate more than listening to someone else”* or *“practicing helps a better retention of the content than lectures”*. Perhaps most of them agree with the student that stated *“...both lectures and game classes complete each other and are both relevant”*.

Figure 1



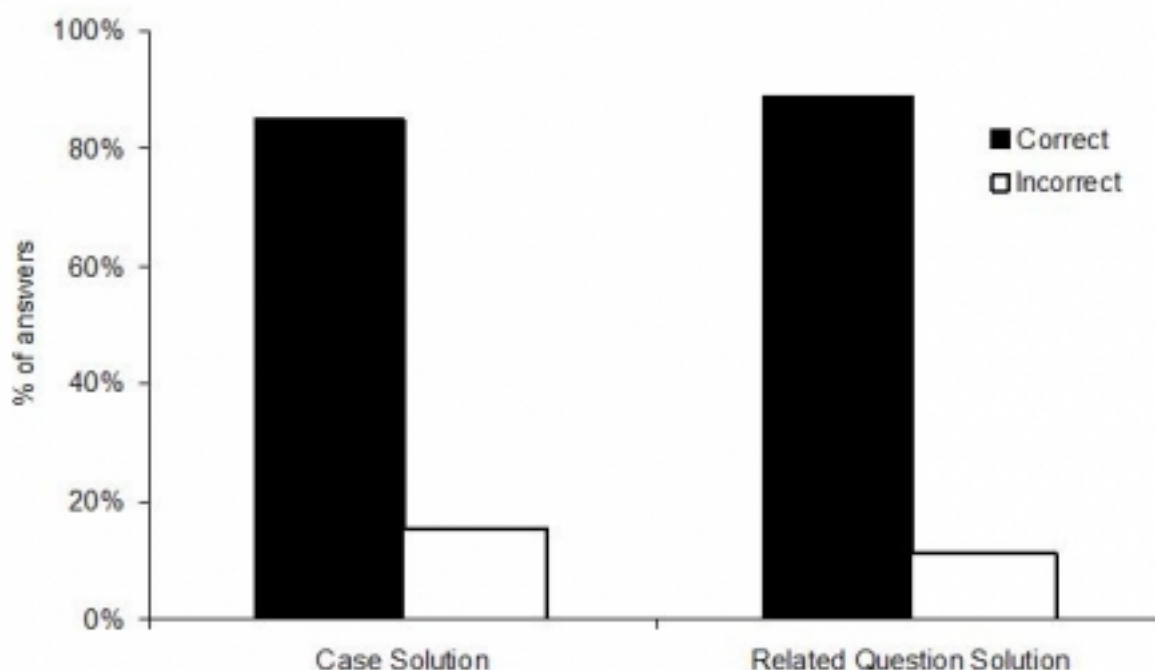
An analysis of the easiness of the *Clue cards* and the *Case* was performed to verify the adequacy for undergraduate students. The mean value for easiness for the clues was 6.0 while that for the *Case* was 4.4 (**Fig. 2**). The higher difficulty level for the *Case* suggests that game difficulty is probably more related to the reasoning and the establishing of correlations between the contents of each card than to the comprehension of each of the *Clue cards*.

Figure 2



The *Case* could be solved by at least one team of students within the allowed period (45-50 minutes). The majority of teams (72.4%) solved the *Case* afterwards and 83.9% of the students were able to correctly answer to the related question (**Fig. 3**). In addition, 80.4% of the students (n=180) correctly answered the central question of the *Case* on a test applied a month after the game.

Figure 3



Conclusion

The *Celula Adentro* game reveals itself as an effective complementary tool for Cell Biology teaching for undergraduate students, as they were able to solve both the Case and a related question about cytoskeleton functions. Taken together, our results indicate great acceptance of a game strategy among undergraduate students, leading them to a more active role on classroom. The game also offers them an opportunity to learn cell biology in an interactive, motivating and enjoyable manner. Therefore, we believe that strategies such as games must be further developed, evaluated and applied in addition to expositive classes (lectures) and even practical lessons among undergraduate students.

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CITACIÓN

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